CLAIMS

1. An image processing method for obtaining a glassless image from a color frontal facial image bearing glasses, comprising the steps of:

a) receiving an RGB color frontal facial image bearing glasses, wherein RGB are red-, green-, and blue-component contained in the received RGB color frontal facial image;

b) extracting candidates of eye regions from the received RGB color frontal facial image;

c) determining an exact eye region out of the candidates and normalizing the received RGB color frontal facial image in a predetermined size by centering on the determined eye region;

d) extracting a glasses frame region by using color information contained in the received RGB color frontal facial image and edge information of a glasses frame;

e) performing an RGB-HSI transformation on the normalized frontal facial image;

f) generating H', S', and I' glassless compensated images on the basis of the RGB-HSI transformed H-, S-, and I-component normalized frontal facial images, wherein the H-, S-, and I-component represent a hue, a saturation, and an intensity, respectively;

g) obtaining R', G', and B' compensated images by performing an HSI-RGB transformation on the H', S', and I' glassless compensated images; and

h) creating a glassless final color facial image on the basis of the R', G', and B' compensated images,

wherein the step f) further comprises the steps of:

f1) obtaining H-, S-, and I-component reconstructed images by reconstructing the H-, S-, and I-component normalized frontal facial images;

f2) obtaining H-, S-, and I-component first differential images between the H-, S-, and I-component normalized frontal facial images and the H-, S-, I-component reconstructed images;

f3) obtaining H-, S-, and I-component second differential images by stretching H-, S-, and I-component first differential images on the basis of pixel information contained in the H-, S-, and I-component first differential images;

f4) determining thresholds to classify the H-, S-, and I-component second differential images into occlusion regions, non-occlusion regions, and uncertain regions;

f5) obtaining an I-component third differential image by including the extracted glasses frame region onto the uncertain region classified by the threshold within the I-component second differential image;

f6) classifying the H- and S-component second differential images and the I-component third differential image on the basis of the thresholds to determine a weight to be applied on the respective classified images; and

f7) obtaining the H', S', and I' compensated images by applying the weight on each of the H- and S-component second differential images and the I-component third differential image.

2. The image processing method of Claim 1, wherein the H-component normalized frontal facial image is expressed as H_x- and H_y-vector-component images as follows:

$$H_x = \cos(H)$$
$$H_y = \sin(H)$$

wherein H'_x and H'_y compensated images are obtained on the basis of the H_x- and H_y-vector-component images.

3. The image processing method of Claim 2, wherein the H'-component glassless compensated image is obtained from the H'_x and H'_y compensated images as follows:

$$H''_X = \frac{H'_X}{\sqrt{H'^2_X + H'^2_Y}}$$
$$H' = \cos^{-1}(H''_X)$$

wherein H''_X is obtained by normalizing H'_x with $(H'^2_X + H'^2_Y)^{1/2}$.

4. The image processing method of Claim 1, wherein the H', S', and I'

compensated images are obtained by a principal component analysis (PCA) reconstruction, and

the step c) further comprises the steps of:

c1) obtaining first and second transformed images on the basis of color information contained in the received RGB color frontal facial image; and

c2) normalizing the received RGB color frontal facial image by using the first and second transformed images.

5. The image processing method of Claim 4, wherein the first and second transformed images are a generalized skin color distribution (GSCD) image and a black and white color distribution (BWCD) image, respectively.

6. The image processing method of Claim 5, wherein the color information is gray-level pixel information.

7. The image processing method of Claim 5, wherein the stretching at step f3) is performed as follows:

$$D(i) = \left(\hat{\Gamma}(i)d(i)\right)^{1/2}$$

wherein $D(i)$ represents the H-, S-, and I-component second differential images, $\hat{\Gamma}(i)$ represents the H-, S-, and I-component reconstructed images generated during performing the PCA reconstruction, d(i) represents the H-, S-, and I-component first differential images, and i is an index for indicating pixels in each image.

8. The image processing method of Claim 5, wherein the occlusion regions contain the glasses and errors due to a reflection and shade by the glasses within the received RGB color frontal facial image.

9. The image processing method of Claim 8, wherein the step f4) further comprises the steps of:

inversing the first transformed image;

performing an OR operation on the inversed first transformed image with the second transformed image;

determining an average of errors within the OR operated image as a lower

threshold; and

determining an average of errors greater than the lower threshold within the OR operated image as an upper threshold.

10. The image processing method of Claim 9, wherein the upper and lower thresholds are determined as follows:

$$T_L = mean(D(j)),$$
where, $j \in$ skin region
$$T_H = mean(D(k)),$$
where, $k \in \{j | D(j) > T_L\}$, $j \in$ non-skin region

wherein T_L and T_H represent the lower and upper thresholds, respectively, $D(j)$ represents errors of skin regions corresponding to the non-occlusion regions within the H-, S-, and I-component second differential images, and $D(k)$ represents errors of non-skin regions corresponding to the occlusion regions within the H-, S-, and I-component second differential images.

11. The image processing method of Claim 10, wherein the occlusion regions in the I-component second differential image includes the glasses frame region, which is extracted as follows:

$$\text{If}, D(i) < T_H$$
then
$$D'(i) = \max(D(i), G(i)),$$
where, $i = 1, \cdots, N$
$$\text{if}, D(i) \geq T_H$$
then
$$D'(i) = D(i)$$

wherein the I-component third differential image is obtained on the basis of the I-component second differential image including the glasses frame region, D'(i) represents the I-component third differential image, and G(i) represents gray-level values of the extracted glasses frame region.

12. The image processing method of Claim 11, wherein the weights are

determined as follows:

$$\text{If}, D'(i) \geq T_H$$
$$\text{then}$$
$$\omega(i) = 1$$
$$\text{if}, T_L \leq D'(i) < T_H$$
$$\text{then}$$
$$\omega(i) = 1 - 0.5\frac{T_H - D'(i)}{T_H - T_L}$$
$$\text{else}$$
$$\omega(i) = 0$$

wherein a weight of 1 is applied on regions having error values greater than the upper threshold within the I-component third differential image, a weight of 0 on regions having error values less than the lower threshold, and a weight with a value from 0.5 to 1 on regions having error values between the upper and lower thresholds, and

wherein the regions having the error values greater than the upper threshold are the occlusion regions, the regions having the error values less than the lower threshold are the non-occlusion regions, and the regions having the error values between the upper and lower thresholds are the uncertain regions.

13. The image processing method of Claim 12, wherein the occlusion regions within the I-component third differential image are compensated as follows:

$$\text{If } (t = 0)$$
$$\text{then}$$
$$\Gamma_t'(i) = \omega \cdot \varphi + (1 - \omega) \cdot \Gamma(i)$$
$$\text{else}$$
$$\Gamma_t'(i) = \omega \cdot \hat{\Gamma}_t(i) + (1 - \omega) \cdot \Gamma(i)$$

wherein $\Gamma_t'(i)$ represents the I' compensated image, ω represents the weights, φ represents an I-component average image, $\hat{\Gamma}_t(i)$ is the I-component reconstructed image, and $\Gamma(i)$ is the I-component normalized frontal facial image.

14. The image processing method of Claim 10, wherein a weight of 1 is applied

on regions having error values greater than the upper threshold within the H- and S-component second differential images, a weight of 0 on regions having error values less than the lower threshold, and a weight with a value from 0.5 to 1 on regions having error values between the lower and upper threshold,

wherein the regions having the error values greater than the upper threshold are the occlusion regions, the regions having the error values less than the lower threshold are the non-occlusion regions, and the regions having the error values between the upper and lower thresholds are the uncertain regions.

15. The image processing method of Claim 14, wherein the occlusion regions within the H- and S-component second differential images are compensated as follows:

If $(t=0)$
then
$\Gamma_t'(i) = \omega \cdot \varphi + (1-\omega) \cdot \Gamma(i)$
else
$\Gamma_t'(i) = \omega \cdot \hat{\Gamma}_t(i) + (1-\omega) \cdot \Gamma(i)$

wherein $\Gamma_t'(i)$ represents the H' and S' compensated images, ω represents the weights, φ represents H- and S-component average images, $\hat{\Gamma}_t(i)$ is the H- and S-component reconstructed images, and $\Gamma(i)$ is the H- and S-component normalized frontal facial images.

16. The image processing method of Claim 13 or 15, further comprising the step of repeating the steps f1) to f7),

wherein the H', S', and I' compensated images obtained at step f7) are used at step f1) instead of the H-, S-, and I-component normalized frontal facial images when performing the repeating step.

17. The image processing method of Claim 16, further comprising the steps of:

determining whether each difference between the H', S', and I' compensated images obtained at step f7) and H', S', and I' compensated images obtained after performing the repeating step is less than the predetermined value or not;

performing, if each difference is less than the predetermined value, the HSI-

RGB transformation on the H', S', and I' compensated images obtained after performing the repeating step, to thereby obtain the glassless final color facial image based on the transformed H', S', and I' compensated images obtained after performing the repeating step; and

performing the repeating step, if each difference is greater than the predetermined value.